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Throat Hit in Users of the Electronic Cigarette: An Exploratory Study

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A cross-sectional survey on the Internet in 2012–2014 was used to study the “throat hit,” the specific sensation in the throat felt by users of e-cigarettes. Participants were 1672 current users of e-cigarettes, visitors of Websites dedicated to e-cigarettes and to smoking cessation. It was assessed whether the strength of the throat hit was associated with the characteristics of e-cigarettes and e-liquids, modifications of the devices, patterns of use, reasons for use, satisfaction with e-cigarettes, dependence on e-cigarettes, smoking behavior, and perceived effects on smoking. The strongest throat hit was obtained by using better-quality models and liquids with high nicotine content. Those who reported a “very strong” throat hit used liquids with 17.3 mg/mL nicotine, versus 7.1 mg/mL for those reporting a “very weak” hit ($p < .001$). The strength of the throat hit was also associated with ratings of dependence on e-cigarettes, and with the perceived efficacy of e-cigarettes to relieve craving for tobacco and to facilitate smoking cessation. All the variables assessing satisfaction with e-cigarettes were associated with a stronger throat hit. From a public health perspective, there is a trade-off between e-cigarette models that provide high levels of nicotine, a strong throat hit, high satisfaction, and more effects on smoking, but may also be addictive, and models than contain less nicotine and are less addictive, but produce a weaker throat hit, are less satisfactory, and are possibly less efficient at helping people quit smoking. This trade-off must be kept in mind when regulating e-cigarettes.

Keywords: electronic nicotine delivery devices (ENDS), electronic cigarette, e-cigarette, nicotine, smoking

The combustion of cigarettes produces many toxic substances that are not originally present in the tobacco plant. Combustion must now compete with new, safer technologies that vaporize nicotine for inhalation, including electronic cigarettes (e-cigarettes), electrically heated tobacco products, and other technologies (Hajek, Etter, Benowitz, Eissenberg, & McRobbie, 2014; Kogel et al., 2014; Moyses, Hearn, & Redfern, 2015; Rose, Turner, Murugesan, Behm, & Laugesen, 2010). If such products ended up replacing a substantial part of the cigarette market, these technologies would have a large impact on smoking-related mortality. In particular, e-cigarette use is increasingly prevalent, and e-cigarettes are more popular than medical nicotine inhalers (Beard, Brown, McNeill, Michie, & West, 2015; Hajek et al., 2014; Pepper & Brewer, 2014). One reason for their success could

be the “throat hit,” that is, the specific sensation felt in the back of the throat by users when they inhale vapors from e-cigarettes (Barbeau, Burda, & Siegel, 2013). Throat hit is a topic that is frequently discussed in online discussion forums and on commercial Websites, where “vapers”—users of e-cigarettes—seek products and advice on how to obtain an optimal throat hit. However, there is very little published research on the throat hit and the factors associated with it, for example, characteristics of the device and refill liquid (“e-liquid”), characteristics of users, satisfaction, effects on craving for tobacco, and effects on smoking behavior (Barbeau et al., 2013; Farsalinos et al., 2014; McQueen et al., 2011). From previous research, we only know that newer models of e-cigarettes produce a stronger throat hit than do older models (Farsalinos et al., 2014), and that high-voltage batteries produce more vapor and a better throat hit, but the latter information comes from interviews with e-cigarette users rather than from quantitative assessments (McQueen, Tower, & Sumner, 2011). We know of no systematic study of the throat hit in vapers.

In contrast, there is a large body of literature on throat sensations in cigarette smokers. Tobacco manufacturers have understood for a long time the importance of throat sensations, and that nicotine levels in cigarettes, and in particular the amount of freebase nicotine (Ferris Wayne, Connolly, & Henningfield, 2006), determine these sensations and the nicotine “kick” reported by smokers (Dixon, Kochhar, Prasad, Shepperd, & Warburton, 2003; Hurt & Robertson, 1998; Pankow, 2001; Stevenson & Proctor, 2008). Manufacturers also use menthol to attenuate the harshness and irritation of smoke (Kreslake, Wayne, & Connolly, 2008). Research conducted in the 1990s also supports the importance of throat sensations in smokers. For instance, in smokers who stopped smoking, a citric acid inhaler, which reproduced some of the throat

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sensations of smoking, improved smoking abstinence rates in the short term (Westman, Behm, & Rose, 1995). In smokers who abstained from smoking, a black pepper inhaler reduced tobacco withdrawal symptoms (Rose & Behm, 1994). All these studies suggest that it is useful to explore the determinants and effects of the throat hit in e-cigarette users.

Thus, the aim of this study was to provide a detailed description of the variables associated with the throat hit reported by e-cigarette users. A better comprehension of the throat hit is useful for manufacturers and retailers, for clinicians, for researchers who design clinical studies, for policymakers (who regulate e-cigarettes and refill liquids), and for vapers, to help them choose the products that best help them to quit smoking.

On the basis of previous research on electronic and combustible cigarettes, it was hypothesized that the strength of the throat hit would be associated with the nicotine concentration in e-liquids, with more satisfaction and with more perceived effects on smoking cessation and reduction.

Method

Materials

The data used in the present study were collected in an online survey of e-cigarette users, aimed at providing an in-depth description of their behavior. These data were not collected specifically for the throat hit analysis. This online survey builds on previous research in vapers (Dauptcheva, Gmel, Studer, Deline, & Etter, 2013; Etter, 2010; Etter & Bullen, 2011a, 2011b, 2014). Two other studies based on the same data set have been published (Etter, 2015; Etter & Eissenberg, 2015). The questionnaire was posted on the smoking cessation Website Stop-Tabac.ch, in English and French, between October 2012 and April 2014 (Etter, 2008; Etter & Hughes, 2006). This website was chosen because it is managed by the author. Discussion forums and Websites informing about e-cigarettes or selling them were contacted, and asked to publish links to the survey (<http://www.stop-tabac.ch/en/ECIG2012/>). Participants were >18 years old, and only current users of e-cigarettes were eligible. The study was approved by the ethics committee of the Geneva University Hospitals. Consent was implicit, and participants were informed that their answers would be retained on file and would not be transmitted to any third party. Participants were not compensated.

The questionnaire assessed the following:

Prior and current use of e-cigarettes (“Are you currently using the electronic cigarette?” We included only those who answered, “Yes, I use it every day” and “Yes, occasionally (not daily).”)

Duration of use, nicotine content, puffs/day, brand and model (open text fields), cost, flavors, propylene glycol (PG) or vegetable glycerin (VG), where e-cigs are purchased.

Use of prefilled cartridges, unmodified tank systems, or modular systems modified by the users. Modifications of the e-cigarette and e-liquid, reasons to modify them (closed-format questions).

Throat hit: “Please describe the ‘throat hit’ of the e-cigarette you currently use most,” with five response options (very strong, rather strong, average, rather weak, very weak).

Perceived effect of vaping on smoking reduction, smoking cessation, and relapse.

Self-report of dependence on the e-cigarette (0–100 scale), feeling like a prisoner of the e-cigarette, time to first puff on e-cigarette in the morning (an indicator of dependence; Courvoisier & Etter, 2010; Etter & Eissenberg, 2015; Etter, Le Houezec, & Perneger, 2003). In former smokers, comparison of dependence on e-cigarettes with their former dependence on tobacco cigarettes (three response options: weaker, same, stronger).

Ever used e-cigarettes in place of smoking cessation medications.

Satisfaction with the e-cigarette and reasons to use them.

Smoking status, combustible cigarettes per day and time to first cigarette now and before using e-cigarettes.

Currently trying to quit or reduce smoking, intention to quit smoking.

Age and sex, country, and Website where respondents learned about the survey (open text field). Websites were categorized as related to e-cigarettes (i.e., commercial or discussion forums) or neutral (Google, Smokefree.gov, and Stop-tabac.ch).

IP addresses (i.e., computer numbers) to identify and delete duplicate records.

Statistical Analyses

Bivariate analyses. Analysis of variance (ANOVA) models and *t* tests were used to compare means, Kruskal-Wallis tests to compare medians, and chi-square tests to compare proportions. For most variables, medians rather than means are reported, because medians are less sensitive to extreme values. Linear regression models were used to test associations between continuous variables. Prices in currencies other than U.S. dollars were converted to U.S. dollars. Holm-Bonferroni corrections were used for multiple comparisons for all the bivariate analyses, and thus only *p* values of $\leq .001$ were considered statistically significant.

Multivariate analyses. Multivariate linear regression models were used to identify the variables that were independently associated with the strength of the throat hit (the dependent variable, considered continuous), using stepwise regression. Only the variables that were significantly ($p < .001$) associated with the throat hit in bivariate analyses were included in the multivariate models (see the Results section for a list of these variables). Four models were tested: (a) device characteristics and modifications; (b) effects of the throat hit; (c) satisfaction; and (d) reasons to use e-cigarettes.

Results

Participants

Answers from 1,672 current users of e-cigarettes were obtained. The median age of participants was 41 years; most were men (62%) and former smokers (80%; see Table 1). None of the participants had never used tobacco. Distribution of respondents by country was as follows: France (35%), United States (21%), Switzerland (11%), United Kingdom (5%), Belgium (3%), Canada (2%), and other countries (23%).

Daily smokers (i.e., dual users) smoked 10 combustible cigarettes per day on average, compared with 20 cigarettes/day before they started using e-cigarettes (paired-samples *t* test, $t = 11.3$, $p < .001$). Most daily smokers were currently trying to reduce their tobacco use (88%), or were trying to quit smoking (66%), and 28% had decided to quit in the next 30 days. Almost all daily smokers (91%) said e-cigarettes helped them smoke fewer combustible cigarettes.

Former smokers had quit smoking 4.6 months before they took the survey, and had been using the e-cigarette for 5 months (medians).

Utilization of E-Cigarettes

Most participants (92%) used e-cigarettes daily, and 8% used them occasionally. Most (96%) used refillable tank systems, and a few (4%) used prefilled cartridges. A majority (60%) used modular systems (i.e., their own combination of batteries and atomizers). The median duration of the current episode of e-cigarette use was 5 months, but 26% had been using the e-cigarette for 1 or more years. Almost all participants (94%) used e-cigarettes containing

nicotine (see Table 2). The median nicotine concentration in the liquids was 12 mg/mL (see Table 2). Most participants (72%) bought their e-cigarettes on the Internet. For their e-liquids, most participants (78%) used a mix of propylene glycol (PG) and (vegetable glycerin (VG), rather than PG only (9%) or VG only (7%).

Brands and Models

The most frequently used e-cigarette brands (open text field) were Joye/Joyetech (20% of respondents), Ego (14%), Provari/Provape (7%), Innokin (5%), Kanger (4%), and Vision (3%); 47% indicated other brands. The most used models were the Ego (36%, sold under various brand names), the Provari by Provape (5%), and the V2, V3, and V5 by Vamo (4%); 55% indicated other models. The most frequent (11%) response category to the open-text question on the most used brand of refill liquids was “home made,” “do it yourself,” or “self mixed.” The flavors used most were tobacco (35% of participants), various fruits (18%), mint-menthol (14%), RY4 (5%; RY4 is a mixed caramel/tobacco flavor), coffee (4%), and vanilla (4%).

Participant Characteristics and Throat Hit

Four percent of participants reported a “very weak” throat hit from their e-cigarette, 10% a “weak” hit, 49% an “average” hit, 32% a “rather strong” hit, and 5% a “very strong” throat hit. Compared with participants who reported a “weak” throat hit, those who reported a “strong” hit were younger, more likely to be men, and more likely to have learned about the survey on an e-cigarette Website (rather than on a neutral Website; see Table 1).

Table 1

Characteristics of Current E-Cigarette Users and Strength of the Throat Hit: Internet, 2012–2014

Variable	Strength of the throat hit					Test	<i>p</i>
	Very weak	Rather weak	Average	Rather strong	Very strong		
<i>N</i>	64	169	825	535	79		
Sex (men, %)	48	51	62	67	82	$\chi^2 = 32.3$	<.001
Age ^a	44	44	43	41	40	KW = 32.0	<.001
Has a diploma that gives access to university (%)	58	73	74	80	79	$\chi^2 = 17.0$	.002
Household income above average (%)	31	37	41	39	41	$\chi^2 = 26.1$	.16
Learned about the survey on e-cigarette Website (vs. neutral site) (%)	39	68	80	78	82	$\chi^2 = 21.3$	<.001
Current smokers (%), the rest = former smokers	20	20	16	15	18	$\chi^2 = 20.2$	.06
Current smokers (dual users)							
Tobacco cigarettes/day now ^a	8	5	5	3	9	KW = 7.0	.28
Cigarettes per day before they started using e-cigarette ^a	20	20	20	23	20	KW = 3.0	.69
Minutes to first cigarette of the day ^a	18	18	20	15	10	KW = 2.0	.88
Currently trying to quit smoking (%)	80	67	62	58	80	$\chi^2 = 3.3$	.50
Currently trying to reduce cigarettes/day (%)	90	96	88	86	90	$\chi^2 = 2.0$	.74
Former smokers							
Days since quit smoking ^a	72	107	134	144	285	KW = 19.4	.001
Cigarettes per day before they quit smoking ^a	25	20	20	22	25	KW = 10.6	.021
Minutes to first cigarette of the day, before they quit ^a	15	10	10	10	10	KW = 3.7	.73

Note. For categorical variables, numbers indicate the percentage of participants within a throat hit category who fulfill the criteria in the table rows; for example, 82% of those who reported a “very strong” throat hit were men. For continuous variables, numbers indicate the median for each throat hit category; for example, participants who reported a “very strong” throat hit were on average 40 years old. KW = Kruskal-Wallis test.

^a Median.

Table 2

Patterns of E-Cigarette Use, Characteristics of the Device and Strength of Throat Hit: Internet, 2012–2014

Characteristic	Strength of the throat hit					Test	p
	Very weak	Rather weak	Average	Rather strong	Very strong		
Use e-cigarette daily (the rest = occasionally; %)	89	94	98	98	96	$\chi^2 = 20.4$	<.001
Duration of e-cigarette use (days) ^a	49	152	152	152	274	KW = 27.9	<.001
Minutes to first puff of the day on e-cigarette ^a	30	30	15	20	15	KW = 14.6	.006
Puffs/day on e-cigarette ^a	100	100	170	200	200	KW = 28.8	.001
Milliliters of e-liquid per month ^a	40	50	60	60	85	KW = 26.1	<.001
Monthly spending on e-cigarettes + liquids (U. S. dollars) ^a	27	40	45	48	54	KW = 18.6	.001
Buy e-cigarette on Internet (%)	57	61	75	73	73	$\chi^2 = 60.7$	<.001
Intend to use e-cigarette for 1 or more years (%)	21	28	33	40	43	$\chi^2 = 77.9$	<.001
Used e-cigarette in place of smoking cessation medication for ≥ 3 months	15	35	38	41	42	$\chi^2 = 64.5$	<.001
E-liquid contains nicotine (%)	60	85	96	99	96	$\chi^2 = 210.3$	<.001
E-liquid nicotine content (mg/mL) ^a	6	7	12	15	18	KW = 184.5	<.001
Use tobacco flavor (vs. all other flavors) (%)	44	33	32	40	42	$\chi^2 = 12.6$	.013
Refill liquid contains							
Vegetal glycerin only	19	9	5	6	7	$\chi^2 = 59.7$	<.001
Both propylene glycol and vegetal glycerin	44	74	81	79	76		
Propylene glycol only	19	6	7	10	13		
Use prefilled cartridge (%; the rest use refillable tanks)	11	7	3	3	8	$\chi^2 = 42.1$	<.001
Use modular system (own combination) vs. commercial model	41	52	61	63	81	$\chi^2 = 33.1$	<.001
Ever modified their e-cigarette (%)	22	28	26	35	50	$\chi^2 = 27.6$	<.001
Ever mixed their own refill liquid (%)	30	36	40	41	49	$\chi^2 = 24.3$	.67
If they mix their own liquid, why + how (%)							
To obtain a better throat hit	22	18	25	43	74	$\chi^2 = 54.8$	<.001
To gradually reduce nicotine intake	50	75	64	49	61	$\chi^2 = 34.5$	.001
I add nicotine	13	44	59	57	68	$\chi^2 = 19.0$	.001
I add flavors	72	88	90	91	89	$\chi^2 = 4.4$	.17
I add propylene glycol	38	59	68	68	70	$\chi^2 = 6.9$	.09
I add vegetal glycerin	61	68	75	75	85	$\chi^2 = 4.1$	.33
If they modified their e-cigarette, reasons why							
To obtain a better throat hit	19	15	42	72	81	$\chi^2 = 99.1$	<.001
To increase the battery voltage	64	55	46	65	57	$\chi^2 = 20.3$	.013
To decrease the battery voltage	43	14	26	25	20	$\chi^2 = 8.7$	.63
To add a high-resistance atomizer	28	47	41	49	49	$\chi^2 = 10.5$	.66
To add a low-resistance atomizer	50	56	61	64	74	$\chi^2 = 9.6$	.58
To increase the amount of vapor	40	74	67	83	71	$\chi^2 = 16.0$	.06
To decrease the amount of vapor	0	4	3	3	7	$\chi^2 = 11.3$	.50

Note. KW = Kruskal-Wallis test.

^a Median.

In current smokers, the strength of the throat hit was not associated with the number of combustible cigarettes smoked per day, nor with time to the first combustible cigarette of the day, nor with the number of cigarettes per day before they started to “vape,” or inhale the vapor from e-cigarettes. In former smokers, the strength of the throat hit was not associated with the previous level of tobacco dependence (assessed with the number of cigarettes smoked per day before quitting and time to first cigarette of the day before quitting). In former smokers, the duration of smoking abstinence was positively associated with the strength of the throat hit (+62 days of abstinence for each point on the 5-point scale assessing throat hit; $p < .001$).

Patterns of E-Cigarette Use and Throat Hit

The throat hit was stronger in daily users of e-cigarettes than in occasional users. Compared with those who reported a “weak” throat hit, those who reported a “strong” hit were more likely to buy their e-cigarette on the Internet, more likely to intend to use

e-cigarettes for another year or more, and more likely to have used e-cigarettes in place of smoking cessation medications.

The duration of e-cigarette use was longer among those who reported a stronger throat hit (+43 days of use per point on the 5-point scale assessing throat hit; $p < .001$). Those who experienced a stronger throat hit also used a larger volume of e-liquid per month (+5.7 mL of e-liquid per month for each point on the throat hit scale; $p = .001$; see Table 2).

Device Characteristics and Throat Hit

The throat hit was stronger in those who used nicotine-containing e-liquids. Among users of nicotine-containing refill liquids, participants used an additional 2 mg/mL of nicotine for each point on the 5-point throat hit scale (7.8% of variance explained; $p < .001$). Those who reported a “very strong” hit used e-liquids with 17.3 mg/mL nicotine, versus 7.1 mg/mL for those reporting a “very weak” hit ($p < .001$). None of those who reported a “very weak” throat hit used liquids containing >20

mg/mL nicotine, compared with 26% of those who reported a “very strong” hit.

Compared with those who reported a “weak” throat hit, those who reported a “strong” hit were more likely to use modular systems rather than unmodified devices, they were more likely to use refillable tanks rather than prefilled cartridges, and they were more likely to use either PG or a mix of PG and VG rather than VG only. Those who reported a “strong” hit were more likely than those who reported a “weak” hit to have modified their e-cigarette (see Table 2). No brand of e-cigarette or e-liquid, and no flavor, produced a stronger throat hit than other brands or flavors.

Modifications of the Products and Throat Hit

Compared with those who reported a “weak” throat hit, those who reported a “strong” hit were more likely to mix their own e-liquid with the aim of improving the throat hit. The other modifications of the e-liquid were not significantly associated with the strength of the throat hit (i.e., adding nicotine, PG, VG, or flavors).

Those who reported a “strong” hit were more likely than those who reported a “weak” hit to have modified their e-cigarette with the aim of improving the throat hit. The other modifications were not associated with the strength of the throat hit (i.e., modify the battery voltage, add a variable voltage system, modify the resistance of the atomizer, modify the amount of vapor, “drip” the liquid directly on the atomizer, or improve the taste).

Throat Hit, Perceived Effects on Smoking, Satisfaction, and Side Effects

Compared with those who reported a “weak” throat hit, those who reported a “strong” hit were more likely to report that it was

easy to abstain from smoking when using the e-cigarette, and that the e-cigarette relieved the desire or craving to smoke. In current smokers, however, the strength of the throat hit was not associated with perceptions that the e-cigarette helped them smoke fewer combustible cigarettes (see Table 3).

All the variables assessing satisfaction with the e-cigarette were associated with the strength of the throat hit (see Table 3). In particular, those who reported a “strong” hit were more likely than those who reported a “weak” hit to answer that the quality of their e-cigarette was good, and that they liked the taste of the vapor and the sensation they felt when they inhaled the vapor. Those who reported a “strong” hit were also more likely to have recommended the e-cigarette to their friends.

Compared with those who reported a “weak” throat hit, those who reported a “strong” hit were more likely to report that the e-cigarette irritated their throat, but there was no difference for reports of cough, dry mouth, or dry throat.

Throat Hit and Dependence

The strength of the throat hit was associated with a 0–100 rating of dependence on the e-cigarette (+4.2 points on the dependence scale per point on the 5-point throat hit scale; $p < .001$) and with time to the first e-cigarette puff in the morning (–7.9 min per point on the 5-point throat hit scale; $p < .001$). The strength of the throat hit was also associated with answering that it would be difficult to stop using the e-cigarette, with feeling like a prisoner of the e-cigarette, and with feeling unable to stop vaping (see Table 4).

In former smokers, those who reported a “strong” throat hit were more likely than those who reported a “weak” hit to report that their addiction to the e-cigarette was the same or stronger than their former addiction to cigarettes. However, this item was endorsed by a minority of participants (addiction to the e-cigarette

Table 3
Perceived Effects, Side Effects, Satisfaction, and Strength of the Throat Hit: Internet, 2012–2014

Item	Strength of the throat hit					χ^2	p
	Very weak	Rather weak	Average	Rather strong	Very strong		
Perceived effects on smoking							
Does/did the e-cigarette help you stop smoking? (definitely, %)	70	79	83	86	84	36.9	.012
Easy to abstain from smoking when using the e-cigarette (agree, %)	78	83	87	91	87	43.6	<.001
E-cigarette relieves craving to smoke (definitely, %)	57	63	75	76	83	63.2	<.001
Current smokers: does/did the e-cigarette help you smoke fewer cigarettes? (definitely, %)	69	58	70	76	86	18.9	.27
Satisfaction							
Are you satisfied with the e-cigarette? (extremely, %)	56	42	62	62	68	26.1	<.001
Quality of the e-cigarette model used most (very good, %)	55	47	59	70	87	77.2	<.001
Ever recommended e-cigarette to other people (%)	85	92	95	96	99	42.8	<.001
Are you satisfied with the e-liquid? (very satisfied, %)	56	46	60	67	81	58.5	<.001
Rating of the flavor used most (very good, %)	10	24	34	34	53	67.4	<.001
Like the taste of the vapor produced by e-cigarette (agree, %)	75	78	88	90	88	64.9	<.001
Likes the sensation when inhales vapor (agree, %)	60	81	86	92	91	99.6	<.001
It feels so good to vape (agree, %)	59	68	75	81	91	41.8	<.001
I love vaping (agree, %)	52	63	75	79	90	56.1	<.001
I like the gestures of vaping (agree, %)	47	69	71	73	84	42.3	<.001
Side effects							
E-cigarette causes dry mouth or dry throat (agree, %)	30	43	40	43	34	29.0	.024
E-cigarette irritates your throat (somewhat + strongly, %)	12	34	30	35	36	40.8	<.001
Since I began to use e-cigarette, I cough less (agree, %)	81	81	85	83	92	22.1	.14

Table 4

Dependence on the E-Cigarette, Reasons to Vape, and Strength of the Throat Hit: Internet, 2012–2014

Item	Strength of the throat hit					Test	p
	Very weak	Rather weak	Average	Rather strong	Very strong		
Dependence on e-cigarette							
Addiction to the e-cigarette (scale of 0 to 100) ^a	50	50	65	70	65	KW = 32.9	<.001
I am a prisoner of the electronic cigarette (agree, %)	17	21	26	28	19	$\chi^2 = 43.3$	<.001
I am unable to stop vaping (agree, %)			25			$\chi^2 = 41.4$	<.001
If decided to stop using e-cigarette, likely to succeed (%)	55	36	30	28	42	$\chi^2 = 51.5$	<.001
Stopping using e-cigarette for good would be very difficult (%)	6	23	28	30	35	$\chi^2 = 56.7$	<.001
Felt the urge to vape today (a lot of the time + almost all the time + all the time, %)	15	27	32	35	31	$\chi^2 = 46.5$	.001
Use the e-cigarette because they are addicted to it (very true, %)	2	6	8	9	9	$\chi^2 = 31.2$	.002
Former smokers: addiction to e-cigarette compared to former addiction to tobacco cigarette (same or stronger, %)	12	15	25	25	23	$\chi^2 = 49.7$	<.001
Reasons to use e-cigarette (very true, %)							
Because I enjoy it	45	41	56	60	72	$\chi^2 = 70.1$	<.001
To quit smoking or avoid relapsing	79	86	84	83	87	$\chi^2 = 4.3$	.98
To deal with tobacco withdrawal symptoms	67	60	64	66	67	$\chi^2 = 9.3$	.68
To deal with my craving for tobacco	54	57	64	65	72	$\chi^2 = 27.9$	.006
As a replacement of tobacco with no intention of quitting my nicotine intake	15	15	23	28	37	$\chi^2 = 76.8$	<.001
To deal with situations or places where I cannot smoke	7	17	23	27	33	$\chi^2 = 31.8$	.001
As a nicotine reduction tool, to gradually decrease to 0 mg nicotine	59	44	38	34	24	$\chi^2 = 47.2$	<.001
Because it is less toxic than smoking	60	71	79	80	77	$\chi^2 = 44.4$	<.001

Note. KW = Kruskal-Wallis test.

^a Median.

stronger than former addiction to tobacco cigarettes = 3%; same = 20%; weaker = 77%).

Reasons for Use and Throat Hit

Those who reported a “strong” throat hit were more likely than those who reported a “weak” hit to use the e-cigarette because they enjoyed vaping, as a replacement for tobacco with no intention of quitting their nicotine intake, as a nicotine reduction tool (i.e., to gradually reduce nicotine to 0 mg), and because e-cigarettes were perceived as less toxic than smoking. There was no association between strength of the throat hit and saying that they used e-cigarettes to quit smoking or to avoid relapsing to smoking (see Table 4).

Multivariate Models

Device characteristics and modifications. In the multivariate model on device characteristics and throat hit, the only variables that were independently associated with the strength of the throat hit were the use of nicotine-containing liquids ($\beta = 0.10$, $t = 2.1$, $p = .02$), the nicotine concentration in the liquids ($\beta = 0.30$, $t = 8.1$, $p < .001$), and modification of the e-cigarette with the aim of improving the throat hit ($\beta = 0.32$, $t = 8.8$, $p < .001$).

Effects. In the multivariate model on the effects of the throat hit, the only variables that were independently associated with the strength of the throat hit were the feeling that it is easy to abstain from smoking when vaping ($\beta = 0.06$, $t = 2.5$, $p = .014$), the 0–100 rating of dependence on e-cigarettes ($\beta = 0.16$, $t = 5.0$, $p < .001$), and the feeling that e-cigarettes irritate the throat ($\beta = 0.05$, $t = 3.1$, $p = .002$).

Satisfaction. In the multivariate model on satisfaction, the only variables that were independently associated with the strength

of the throat hit were the quality rating of the e-cigarette model used most ($\beta = 0.11$, $t = 4.2$, $p < .001$), the rating of the flavor used most ($\beta = 0.07$, $t = 3.2$, $p = .002$), and liking the sensation felt when inhaling the vapor ($\beta = 0.17$, $t = 6.0$, $p < .001$).

Reasons to use. In the multivariate model on the reasons to use e-cigarettes, the only variables that were independently associated with the strength of the throat hit were using e-cigarettes for enjoyment ($\beta = 0.09$, $t = 3.3$, $p = .001$), using e-cigarettes as a nicotine reduction tool to gradually reduce to 0 mg nicotine ($\beta = 0.11$, $t = 4.2$, $p < .001$), and thinking that e-cigarettes were less toxic than smoking ($\beta = 0.07$, $t = 2.5$, $p = .12$).

Discussion

This report provides a detailed analysis of the “throat hit” reported by e-cigarette users. Vapers reported that they modified their e-cigarettes and e-liquids with the aim of obtaining a better throat hit. The strength of the throat hit was associated with higher nicotine levels, higher satisfaction levels, more perceived effects of vaping on craving and tobacco smoking, and higher levels of dependence on the e-cigarette. Thus, nicotine level, throat hit, satisfaction, perceived efficacy for smoking cessation and reduction, and dependence on the e-cigarette seem to be interwoven. From a public health perspective, there is a trade-off between products that provide high levels of nicotine, a strong throat hit, high satisfaction, and more effects on smoking, but may also be addictive, and products that contain less nicotine and are less addictive, but produce a weaker throat hit, are less satisfactory and are possibly less efficient at helping people quit smoking. This trade-off must be kept in mind when using, recommending, or regulating e-cigarettes, e-liquids, nicotine contents, and flavors.

Nicotine content was independently associated with the strength of the throat hit in the multivariate analysis. This suggests that the

throat hit is largely an effect of nicotine (rather than other substances) transiting through the throat. This is congruent with previous research showing that the throat sensations reported by tobacco smokers is largely due to nicotine, that tobacco cigarettes with the highest nicotine levels produce the strongest throat perceptions and effects (Dixon et al., 2003; Ferris Wayne et al., 2006; Hurt & Robertson, 1998; Pankow, 2001; Stevenson & Proctor, 2008), and that throat sensations are associated with the amount of freebase nicotine in combustible cigarettes (Ferris Wayne et al., 2006). E-cigarettes also deliver a substantial proportion of freebase (rather than protonated) nicotine (El-Hellani et al., 2015).

In a behavioral model, the throat hit is immediately followed by nicotine passage in the blood and brain, which is itself immediately followed by dopamine release in the brain and by the subsequent feeling of pleasure and relief (Rose & Levin, 1991). These data fit within this model, because they show strong associations among throat hit (the conditioned stimulus), nicotine concentration in e-liquids, and satisfaction.

No association between throat hit and flavors was found. Whether the throat hit and the pharmacological effect of nicotine are reinforced or attenuated by flavors (e.g., menthol) and by other substances in the vapor deserves investigation (Kreslake et al., 2008; Villégier et al., 2006).

Former smokers who reported a strong throat hit were as addicted to tobacco before they started to vape as those who reported a weak hit, but they were more likely to report that e-cigarettes currently helped them to deal with craving for tobacco and to avoid relapsing to smoking. In former smokers, there was also a positive association between the strength of the throat hit and the duration of smoking abstinence. These results suggest that e-cigarettes that produce a strong throat hit are needed by some former smokers to avoid relapsing to smoking, independent of their prior level of addiction to tobacco. Because throat hit is strongly associated with nicotine content, limiting the nicotine concentration in refill liquids may be counterproductive for this category of users (e.g., the European Union Directive limits nicotine concentrations in e-liquids to 20 mg/mL; Farsalinos & Stimson, 2014).

In current smokers, the strength of the throat hit was not associated with perceptions that vaping helped them smoke fewer combustible cigarettes. However, all current smokers in this sample smoked very few cigarettes, even those reporting a weak throat hit. Thus, the absence of an association between throat hit and smoking reduction may be explained by the lack of variance in cigarette consumption in this sample of current smokers.

Experimental studies should test whether pursuing stronger throat hits through high-nicotine liquids helps or deters smokers from quitting smoking, and whether it perpetuates nicotine addiction and makes it harder to stop vaping. Experimental studies should also test whether modifying e-cigarettes or e-liquids to strengthen throat hit has unintended health effects, such as inhalation of toxic compounds.

Some variables that were not assessed in this survey may be associated with throat hit, including draw resistance, temperature of the vapor, and particle size. Previous research suggests that citric acid and pepper inhalers have an impact on smoking behavior and withdrawal symptoms (Rose & Behm, 1994; Westman et al., 1995), and the effects of these substances when used in e-cigarettes deserve investigation.

Strengths of this study include a large, international sample, and new insights. However, this study was conducted in a self-selected sample of visitors of Websites dedicated to e-cigarettes and to smoking cessation. It was previously found that vapers enrolled on e-cigarette Websites differ from those enrolled on “neutral” Websites on several accounts (mainly, smoking status and daily use of e-cigarettes), but the opinions of these two groups on e-cigarettes did not differ very much when smoking status was taken into account (Etter & Bullen, 2011a). Nevertheless, it is possible that some respondents gave the answers that they thought might help defend their position (e.g., by reporting more effects on craving and on smoking cessation). Thus, results of this study may have limited generalizability and should be interpreted with caution. Causal inferences cannot be derived from cross-sectional data, and the predictors of throat hit should be investigated in experimental studies. Finally, technology progresses rapidly, and these results may not apply to future e-cigarette models.

Conclusion

This report provides the first detailed description of the determinants and effects of the throat hit reported by e-cigarette users. This descriptive study has heuristic value, because it can guide future technical developments, experiments, and clinical studies.

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